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REPORT OF THE FAA TASK FORCE ON AIRCRAFT SEPARATION ASSURANCE. --ETC(U)
JAN 79 N A BLAKE , E J KOENKE , L F PAGE

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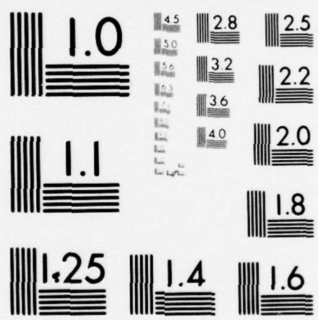

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REPORT OF THE FAA TASK FORCE ON AIRCRAFT SEPARATION ASSURANCE

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JANUARY 1979

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16. Abstract

A task force has developed FAA Engineering and Development consensus on the integrated aircraft separation assurance system for the National Airspace System. This report details a study of system errors, mid-airs, and near mid-airs, and altitude deviations to define the problem. The system element requirements are defined to provide two levels of backup to the ATC system: a separation violation warning and a final fail safe collision advisory and resolution function.

The current FAA ASA development programs are discussed and the changes are detailed which are required to transition to an integrated ASA system. This report consists of three volumes. Volume I is the Executive Summary with an overview of the work performed by the Task Force. Volume II is the detailed main concept description delineating the required systems and interfaces. Volume III includes appendices, referred to in the main report, which define in detail the specific interfaces and designs required for system integration.

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REPORT OF THE FAA TASK FORCE ON

AIRCRAFT SEPARATION ASSURANCE

JANUARY 1979

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1. INTRODUCTION

In July 1977, the Associate Administrator for Engineering and Development (AED) established a task force to develop a technical plan within the Federal Aviation Administration's (FAA) Engineering and Development (AED) for an integrated aircraft separation assurance system for the National Airspace System. The task force consists of Neal A. Blake (AEM-2), Chairman, Edmund J. Koenke (AEM-20), Leland F. Page (ARD-100), and Martin T. Pozesky (ARD-200). This report presents the results of the task force, which include the following:

- development of a summary of mid-air collision, near mid-air collision, system error and altitude deviation data;
- establishment of the functional requirements for the Aircraft Separation Assurance (ASA) system;
- definition of the capabilities and performance of Conflict Alert, Conflict Resolution, Automatic Traffic Advisory and Resolution Service (ATARS), Beacon Collision Avoidance System (BCAS), and Automated Terminal Service (ATS) in meeting the requirements;
- definition of the integrated aircraft separation assurance system;
- determination of the detailed role of each of the system elements listed above;
- definition of the interfaces and interactions among the system elements;
- definition of the design features needed in each of the individual systems to achieve compatibility and allow the individual systems to perform their respective roles properly; and
- identification of needed future activities and management decisions relating to implementation and use of the system.

The task force concluded that the individual ASA elements should be combined into an integrated aircraft separation assurance system. The sections that follow address each of the areas listed above.

Volume I of this report presents an executive summary of the results of this activity. Volume II presents a concept description of the integrated aircraft separation assurance system that was developed. Each individual study supporting the development of the integrated system is presented as a separate appendix in Volume III.

2. MEASURES OF THE AIRCRAFT SEPARATION ASSURANCE PROBLEM

An analysis of statistical data relating to the aircraft separation assurance problem was conducted to:

a) determine the types of separation assurance problems being experienced so that the capability of the individual separation assurance systems to protect against the observed problems could be assessed;

b) gain understanding of the mechanisms by which separation assurance incidents come about, due to human error on the part of pilot or controller or due to other causes, so that the effectiveness of one system relative to another could be assessed and so that changes to individual systems might be recommended to improve their effectiveness;

c) update the statistical information so it is more representative of current operations and so that the effectiveness of recent improvements to the air traffic control system could be assessed.

A previous study analyzed the mid-air collision statistics through the year 1972 (Reference 1). Since that study was published, new data relevant to the separation assurance problem has become available from two sources. One is a study of Air Traffic Control (ATC) system errors reported in Reference 2. (A system error is an event in which two aircraft under the control of the ATC system reach a separation distance less than the published separation minima appropriate for those two aircraft.) The second source is the Aviation Safety Reporting System (ASRS) (References 3 and 4) including altitude deviation data. The ASRS is operated by the National Aeronautics and Space Administration (NASA) to which any person can report a safety incident or a safety hazard with immunity (subject to qualifications) from punitive action. In the following sections, statistics providing four different indications of the separation assurance problem are presented. The four types of statistics are:

a) number of mid-air collisions,

b) number of reported near mid-air collisions

c) number of reported system errors, and

d) number of reported altitude deviations.

2.1 Mid-Air Collision Statistics

Statistics have been compiled from a data base of all mid-air collisions maintained by the National Transportation Safety Board (NTSB). Table 2-1 shows the number of mid-air collisions, and the number of fatalities resulting from mid-air collisions, occurring in the United States each year from 1959 through 1978. During this period, mid-air collisions have been growing to a rate of about 30-35 per year, and fatalities have occurred at the average rate of about 60 per year, but with a standard deviation of about 50.

While the number of mid-air collisions per year in the conterminous U. S. has generally been rather constant over this period as shown in Figure 2-1, the number of aircraft operations per year has been rising. Figure 2-2 shows the change in the mid-air collision rate during this period, expressed as the number of mid-air collisions per million flight hours. In generating this figure, the mid-air collision rate from a given year was computed as the number of mid-air collisions occurring in that year divided by the total flight hours as estimated by the Federal Aviation Administration (FAA) and reported in Reference 5. Figure 2-2 shows that the mid-air collision rate expressed in these terms has been gradually declining over this 12 year period.

Figure 2-3 shows the number of mid-air collisions per year involving air carrier aircraft. None has been involved in a mid-air collision from 1972 to 1977. Figure 2-4 presents a breakdown of the collisions and fatalities for a recent sample of data covering calendar years 1964 through 1978. This figure shows that about 2/3 of the collisions occur within 5 miles of an airport and within 3000 feet of the surface. Among the 177 en route and terminal area collisions, two occurred when both aircraft were being served by the ATC system and were flying according to Instrument Flight Rules (IFR). The problem of collisions between aircraft operating according to Visual Flight Rules (VFR) and IFR is small in terms of the total number of mid-air collisions. However, the potential for many fatalities is high in this type of collision, since heavily loaded air carrier aircraft are exposed to this threat in mixed airspace. (Mixed airspace is airspace in which some aircraft may operate while under the control of ATC at the same time that other aircraft are operating VFR without having contact with ATC.) The VFR/VFR collisions account for the bulk of the en route and terminal area collisions. Half of the VFR/VFR collisions involved aircraft flying in

NUMBER OF MID-AIR COLLISIONS BY SEGMENTS OF AVIATION INVOLVED

YR.	ACCIDENTS TOTAL	ACCIDENTS FATAL	NUMBER FATALITIES	AC/AC	AC/GA	AC/MIL	GA/MIL	GA/GA
57	15	6	19 a/	0	0	1	4	10
58	16	12	86	0	0	2	2	12
59	13	10	20	0	0	0	3	10
60	26	10	152 b/	1	4	0	2	19
61	20	10	22	0	0	0	0	20
62	19	9	27	0	0	0	5	14
63	13	3	6	0	0	0	2	11
64	15	7	12	0	0	0	2	13
65	27	14	30	1	0	0	2	24
66	27	11	33	0	1	0	1	25
67	26	20	157	0	2	1	3	20
68	37	23	69	0	3	0	1	33 c/
69	28	12	122	0	3	0	2	23 c/
70	37	21	55	0	0	0	5	32 c/
71	32	20	96	0	3	1	1	27
72	25	13	41	0	1	0	0	24 c/
73	24	12	29	0	0	0	0	24
74	34	19	48	0	0	0	2	32
75	29	13	47	0	0	0	1	28
76	31	24	64	0	0	0	1	30
77	34	17	41	0	0	0	0	34
78P	34	24	191 d/	0	1	0	0	33
TOTAL	562	310	1,367	2	18	5	39	498

a/Includes 3 persons on ground
b/Includes 6 persons on ground
c/Includes 1 U. S. GA vs. foreign aircraft
d/Includes 7 persons on ground (1978 data preliminary only)

AC: Air Carrier
GA: General Aviation
MIL: Military

Source: NTSB Briefs of Accidents Involving Mid-Air Collisions, January 1978.

Table 2-1
MID-AIR COLLISIONS BY AVIATION SEGMENT
JANUARY 1957 - DECEMBER 1978

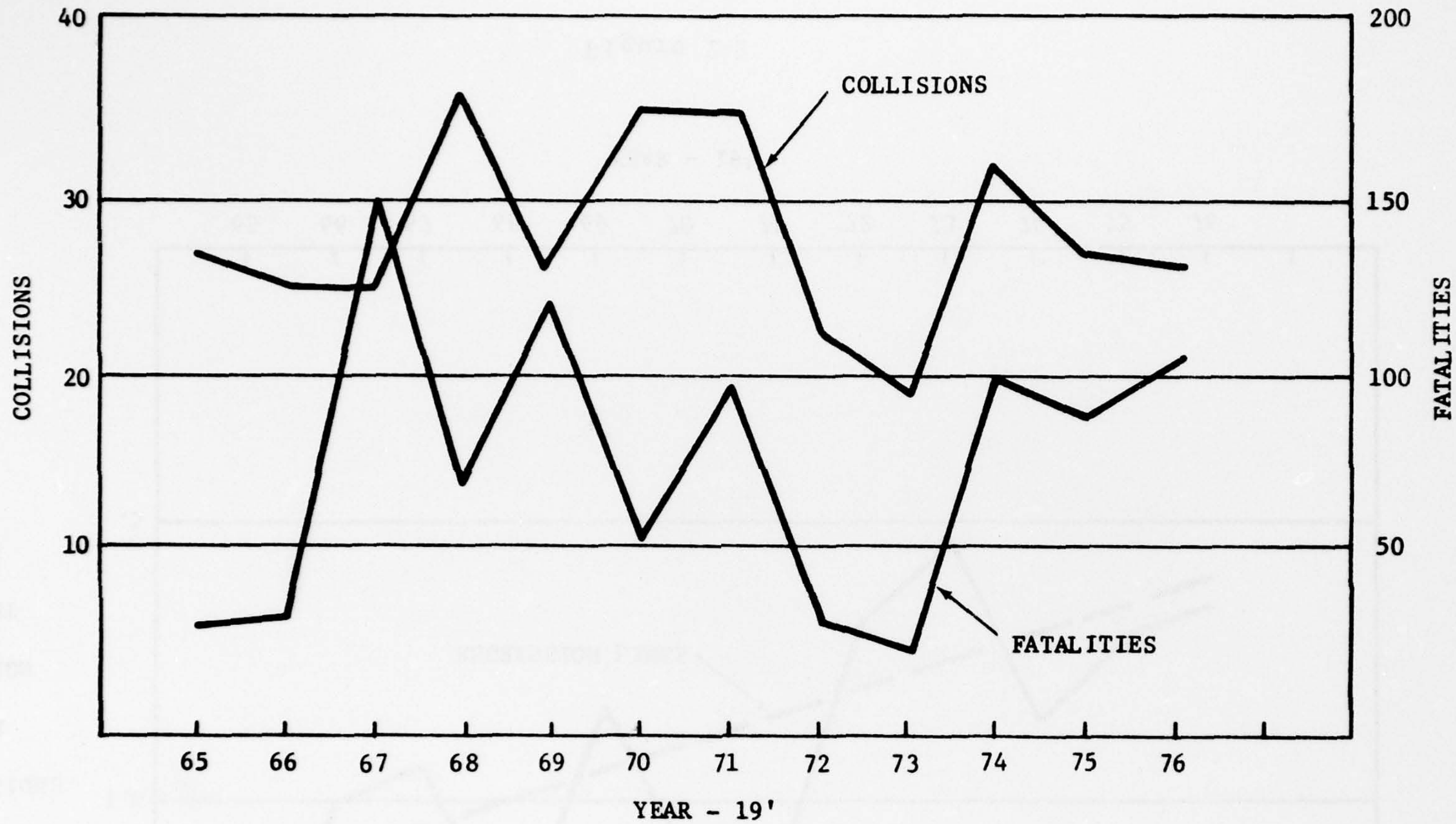


Figure 2-1

YEARLY COLLISIONS AND FATALITIES

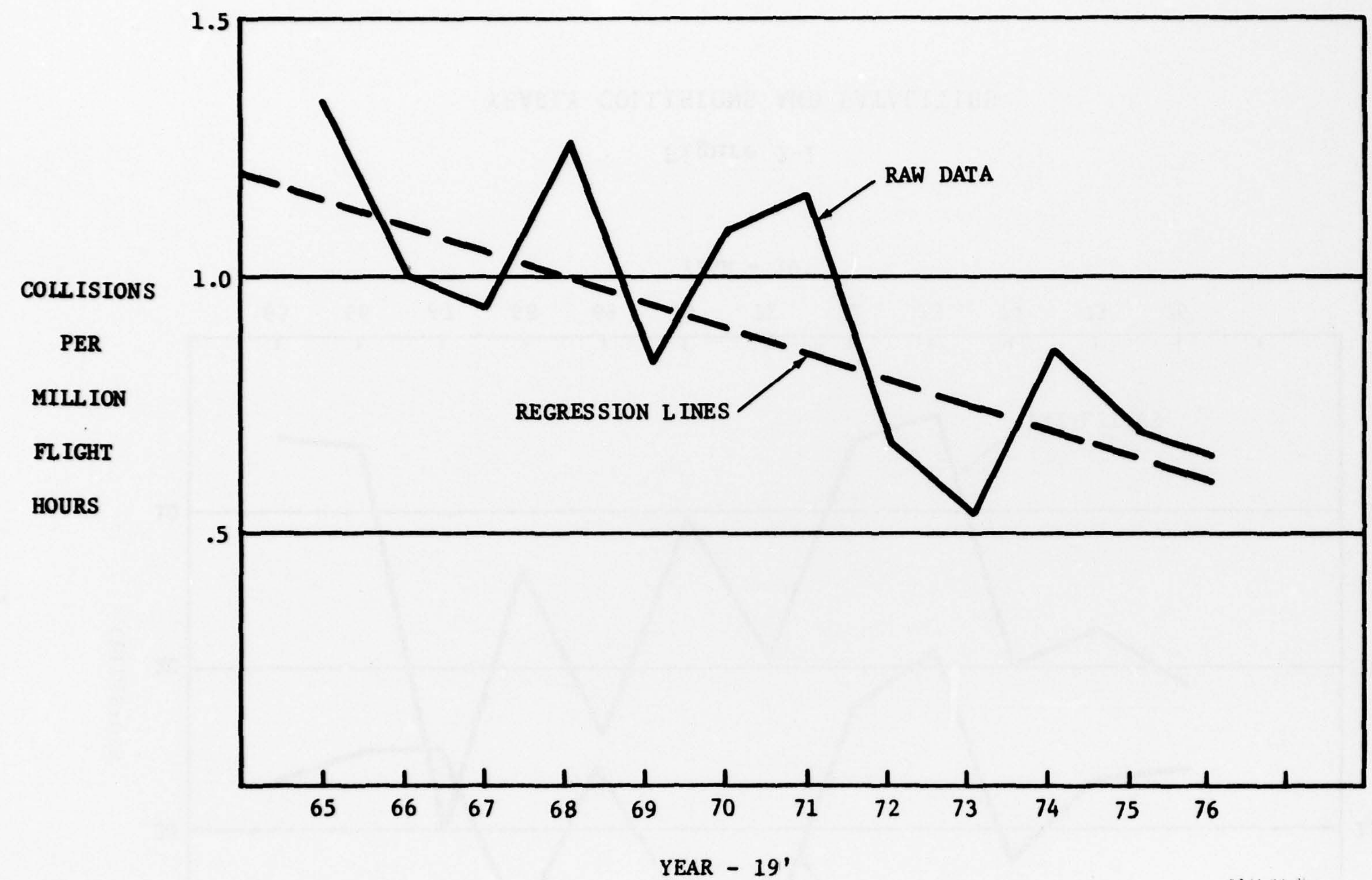


Figure 2-2

MID-AIR COLLISIONS PER MILLION FLIGHT HOURS

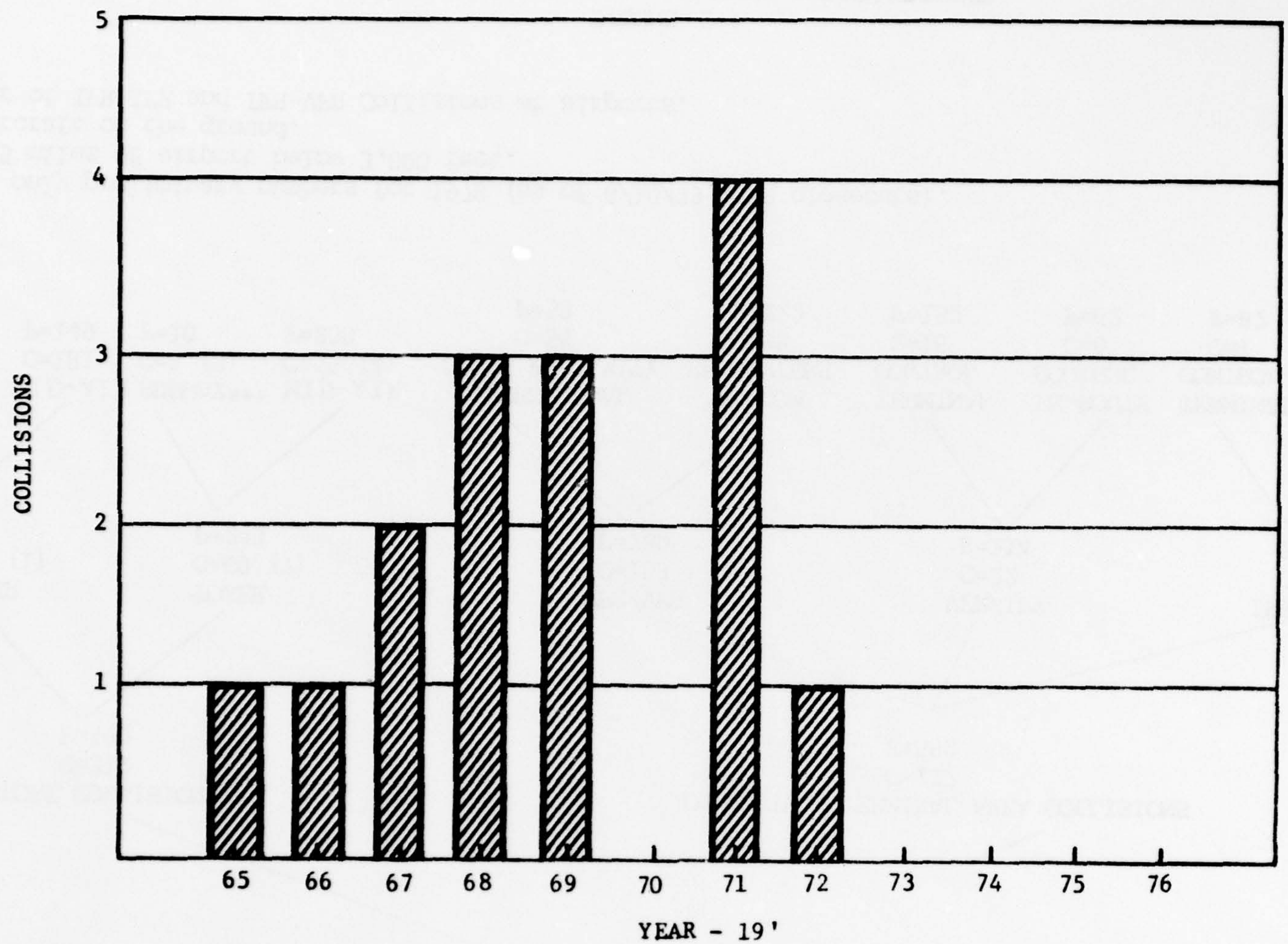
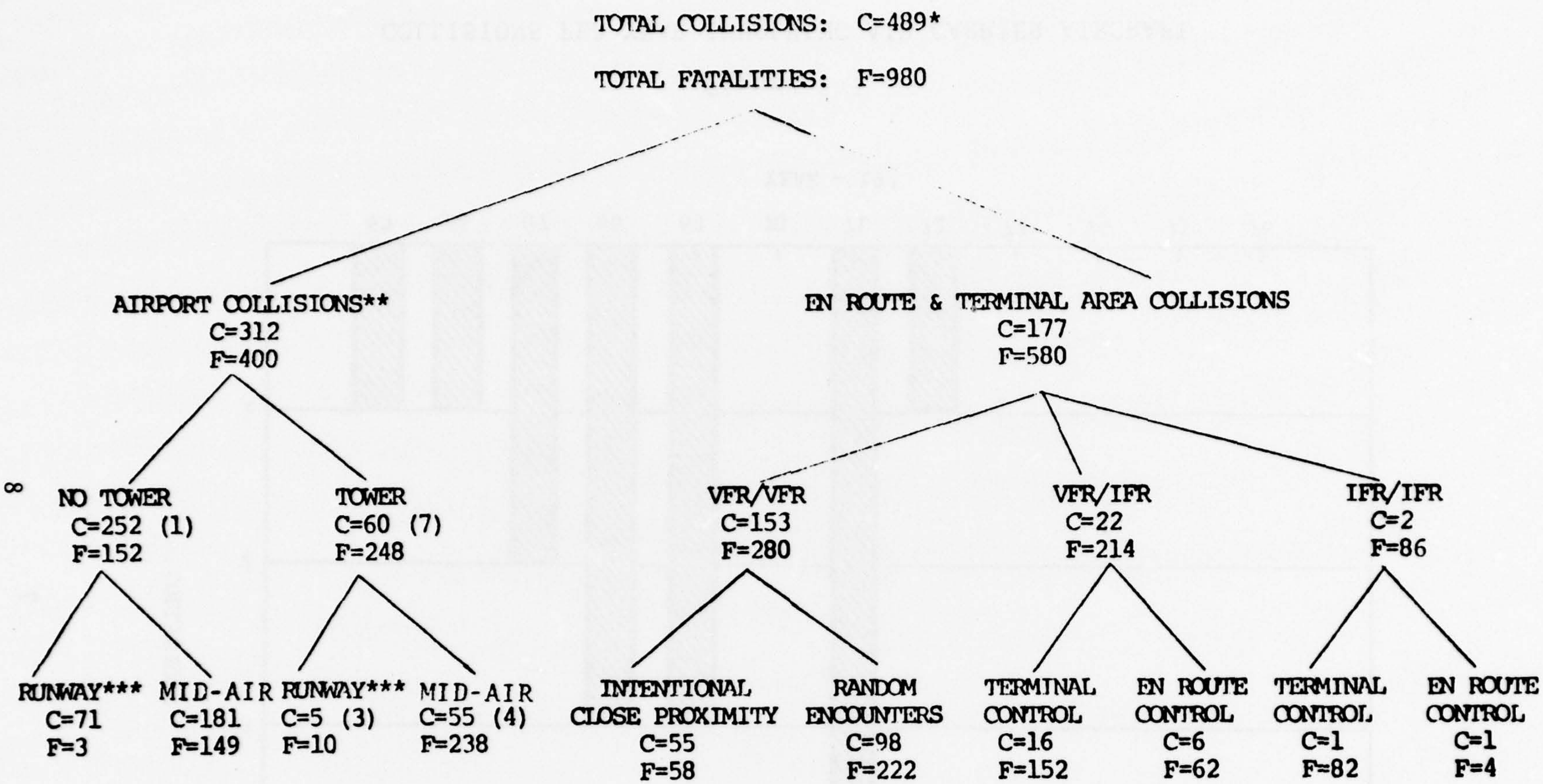


Figure 2-3

COLLISIONS PER YEAR INVOLVING AIR CARRIER AIRCRAFT



*Includes only preliminary numbers for 1978 (as of 6/15/79 NTSB closeouts).
**Within 5 miles of airport below 3,000 feet.
***One aircraft on the ground.
( ) Number of IFR-IFR and IFR-VFR Collisions at airports.

FIGURE 2-4
MID-AIR COLLISIONS BY AIRSPACE REGION/SERVICE
JANUARY 1964 - DECEMBER 1978

intentional close proximity. Table 2-2 presents a listing of the types of activities involved in the close proximity collisions. The separation assurance systems considered in this study could not be and are not intended to be, effective against these types of collisions.

The 177 en route and terminal area collisions presented in Figure 2-4 were analyzed to determine how many occurred within existing ground surveillance coverage. The 55 intentional close proximity collisions and 33 other collisions which occurred at an unknown altitude were not considered. Of the 89 remaining en route and terminal area collisions, 58 were estimated to have been within coverage of a terminal surveillance site (elevation angle greater than 0.5 degrees and within 40 nautical miles) and 21 others were within coverage of an en route surveillance site (elevation angle greater than 0.5 degrees and within 100 nautical miles). (The actual coverage at each specific site was not verified. Terrain features at a particular site could have prevented surveillance of the aircraft at the time of collision even though they satisfied these criteria.) Only 11 of the 89 collisions were not within existing surveillance coverage.

Additional data regarding the mid-air collisions for the period 1964 to 1972 can be found in Reference 1.

2.2 Near Mid-Air Collision Statistics

A near mid-air collision is an incident which would probably have resulted in a collision if no action had been taken by either pilot. Closest proximity of less than 500 feet would usually be required for a potential near mid-air or a definite report received from an air crew member stating that a collision hazard existed between two or more aircraft. Less than 100 feet is required for a critical near mid-air where collision avoidance was due to chance, not pilot action. When such an event occurs, pilots in one or both of the aircraft may report the near mid-air collision along with a description of the circumstances.

Data from two data bases containing near mid-air collision data are presented. One is a data base maintained by the FAA's Flight Standards Service which contains exclusively near mid-air collision data. The other is the ASRS which contains safety reports on potential aircraft conflicts (events in which there was a perceived problem relating to risk of airborne collision) and on other safety hazards.

TABLE 2-2

CLASSIFICATION OF INTENTIONAL CLOSE PROXIMITY MID-AIR COLLISIONS

NUMBER OF MID-AIR COLLISIONS		TYPE OF INTENTIONAL CLOSE PROXIMITY FLYING
1964-1972	1975, 76	
4	6	Formation Flying
15	5	Crop Dusting
5	1	Fish Spotter
6	1	Air Race/Air Show
3	0	Police Helicopter
1	0	Horse Herding
34	13	Total

2.2.1 Flight Standards Near Mid-Air Collision Data

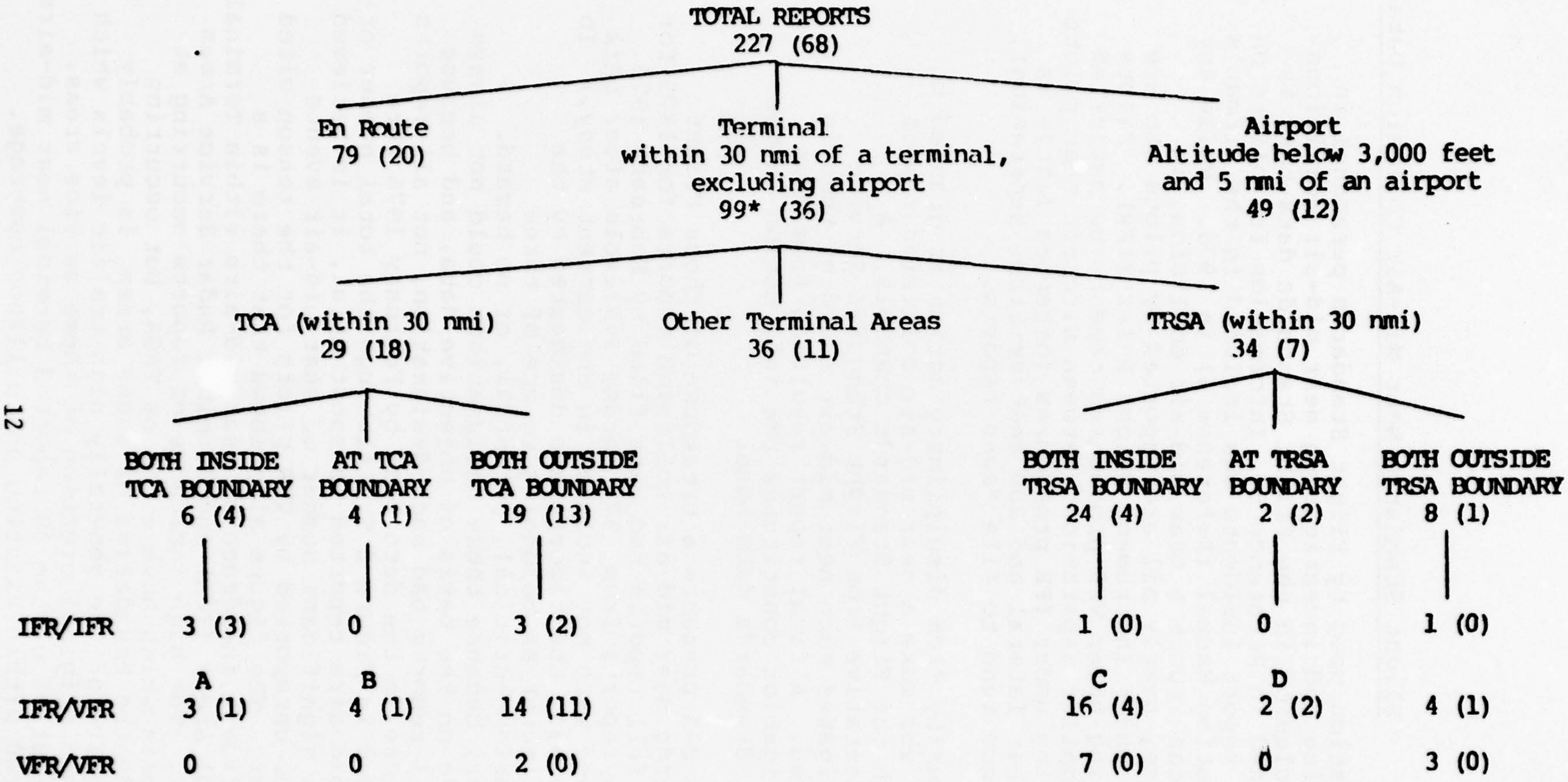
Information used by Flight Standards personnel in reporting and investigating near mid-air collisions for inclusion in the Flight Standards data base is contained in Reference 5. Information for pilots on how to report incidents was included in the Airman's Information Manual (Reference 6) in 1975. While any pilot can report a near mid-air collision, in practice, nearly all are reported by pilots who are flying under Instrument Flight Rules (IFR). Pilots operating under VFR procedures tend to be satisfied with smaller separations between aircraft than pilots operating under IFR procedures (often as little as 1500 feet lateral and 200 feet vertical separation), and hence tend to file fewer reports.

No immunity from disciplinary action is granted to pilots who make a near mid-air collision report through the Flight Standards channels. A representative from Flight Standards Service investigates each near mid-air incident that is reported. A final report resulting from this investigation constitutes the information in the Flight Standards data base.

Figure 2-5 presents a breakdown of those Flight Standards near mid-air collision reports for 1975 for which full reports had been filed by February 1976. (A few reports from 1975 became available after this date and were not included in the current study.) In some cases, the reports are designated by the investigator as belonging to one of three categories--critical, potential, or no hazard. However, because these designations could not always be made on the basis of objective data, and because not all reports had such designation, not all reports that were in the data base by February 1976 were included in Figure 2-5. Although the total number of near mid-airs reported is substantial, it is believed that a significant number of near mid-air events remains unreported by VFR pilots for the reason cited earlier. The figure also shows that there is a significant incidence of near mid-airs within Terminal Control Areas (TCA) and Terminal Radar Service Areas (TRSA). The high incidence of reports occurring at terminals which have a TCA or TRSA, but occurring outside the boundaries of these areas, is probably indicative of the generally high traffic levels which prompted original creation of these service areas. Note that 98 of the 99 reported terminal near mid-airs occurred within existing surveillance coverage.

Figure 2-5

1975 FAA FLIGHT STANDARDS' NEAR MID-AIR COLLISION REPORTS



*98 of 99 terminal reports occurred within existing surveillance coverage
( ) air carrier involved
A - One report involved a VFR aircraft not in contact with ATC
B - Three reports involved VFR aircraft not in contact with ATC, traffic advisories in two of these
C - Two reports occurred with both aircraft participating in TRSA
D - One report occurred with both aircraft participating in TRSA

The rate of involvement of air carrier aircraft in these near mid-air incidents is cause for concern. These data indicate rather clearly that air carrier exposure to collision threats in mixed airspace is present. Introduction of TCA's has reduced the threat of collision for air carrier aircraft within the TCA, but has not been a complete solution to the separation assurance problem, since there are still six near mid-air reports for aircraft within TCA's. A significant separation assurance problem remains in the airspace surrounding the TCA. Figure 2-5 shows that most of the near mid-airs occurring in the vicinity of airports with TCA's involved an IFR and a VFR aircraft. The majority of these IFR/VFR near mid-airs involved air carrier aircraft and occurred outside the TCA in mixed airspace. The introduction of TCAs has not eliminated the mixed air space near mid-air collision problem. It has, presumably, reduced the extent of the problem and has confined the remaining problem to airspace farther removed from the airport. A similar situation exists with respect to Terminal Radar Service Areas. Their introduction has undoubtedly produced some reduction in risk, but has been an incomplete solution to the IFR/VFR near mid-air problem. In 19 of the 22 IFR/VFR near mid-airs at airports with a TRSA, one aircraft (presumably the VFR aircraft) was not participating in the Stage III radar service.

The data presented in Table 2-3 indicate that air carrier aircraft still spend a significant amount of time outside the boundaries of TCA's in mixed airspace where interactions with VFR general aviation aircraft can be expected. This table shows the number of air carrier aircraft at specific instants of time that were below 10,000 feet altitude and outside the boundaries of the TCA at several major hubs. These data were taken from live radar recordings of traffic made at these hubs in late 1974 and early 1975.

2.2.2 The ASRS Near Mid-Air Collision Data

In 1975, the FAA initiated the Aviation Safety Reporting Program. This program was described in Advisory Circular 00-46 (Reference 7). At first, the reports which were filed under this program were maintained by the FAA's Office of Aviation Safety. The program provided for a limited waiver from disciplinary action in certain areas for those who filed the reports. In early 1976, the FAA turned over responsibility for receiving reports from this program and for maintaining the data base to NASA.

TABLE 2-3

AIR CARRIER AIRCRAFT BELOW 10,000 FEET AND OUTSIDE THE TCA

AIRPORT AND CONFIGURATION	TOTAL AIR CARRIERS IN VIEW	AIR CARRIERS INSIDE TCA	AIR CARRIERS BELOW 10,000 FT. AND OUTSIDE TCA		
			TURBOJET	OTHER	TOTAL
WASHINGTON NATIONAL VFR	11	5	1	1	2
MIAMI INTER-NATIONAL PARALLEL RUNWAYS VFR	14	4	4	4	8
MIAMI INTER-NATIONAL PARALLEL RUNWAYS VFR	21	9	10	4	11
CHICAGO O'HARE PARALLEL RUN-WAYS VFR	37	15	12	1	13
CHICAGO O'HARE PARALLEL RUN-WAYS VFR	24	6	11	1	12

Data began to accumulate in the ASRS data base beginning on April 15, 1976. NASA was given responsibility for receiving the safety reports in an effort to provide immunity to pilots making reports of hazards to flying safety. Procedures were developed to preserve the anonymity of the person making the report whenever data from the ASRS data base was provided to users of the data. It was hoped that these steps would broaden the base of those participating in the reporting program.

In addition to the advisory circular, the ASRS was publicized through wide dissemination of posters and pamphlets containing report forms. Articles also appeared in magazines published by several pilot associations. In the ASRS data base, the data are recorded essentially as the reporter described them. In a few cases, a NASA analyst may call the reporter on the telephone for elaboration or clarification, but no investigation is made and no real attempt is made to obtain corroborating data.

The data presented in this section concerning aircraft in potential conflict were provided to the FAA from the NASA ASRS data base. They are based on a total of 4870 safety reports which were in the data as of September 23, 1977. Of these reports, 2108 pertained to aircraft in potential conflict. A potential conflict is defined by NASA as any perceived problem relating to the risk of airborne collision. The actual number of potential conflict events represented by these 2108 reports cannot be determined, since the data provided give no means for identifying duplicate reporting. Roughly half of all reports made to ASRS prior to March of 1977 were made by ATC controllers. The fraction of the near mid-air reports made by controllers cannot be determined.

Table 2-4 shows a breakdown of miss distances for potential conflicts in which the reporter had made an estimate of miss distance. The ability of pilots to estimate miss distances in flight accurately is subject to doubt. However, the number of cases in which pilots estimated the miss distance to be less than 500 feet in any dimension is large enough to be of concern even with allowances for errors in estimation.

TABLE 2-4

ESTIMATED MISS DISTANCES FOR THE POTENTIAL CONFLICT REPORTS IN WHICH ESTIMATED MISS DISTANCE WAS INCLUDED

(NASA ASRS data base as of 9-23-77)

MISS DISTANCE	NUMBER OF REPORTS
Less than 500 feet in any axis	929
500 to 3000 feet horizontal	169
3000 to 10,000 feet horizontal	270
10,000 to 30,000 feet horizontal	29
TOTAL	1397

Table 2-5 presents a tabulation of the number of times evasive action was taken by the reporter. The large number of instances in which evasive action was taken indicates that the pilots considered many of the potential conflicts as serious encounters. The 136 instances in which there was not time for evasive action would seem to represent a measure of the failing of either the see-and-avoid process or the ATC system.

Table 2-6 indicates the number of potential conflicts, with estimated miss distance less than 500 feet in any dimension and in which evasive action was taken, that occurred in various types of airspace. Table 2-7 shows the distribution of the same potential conflicts among the different ATC positions. This data shows that no area is immune from the occurrence of these potential conflicts. It is noted that significant numbers occur in Positive Control Areas and in Terminal Control Areas where all traffic is controlled (except for unauthorized intruders).

Table 2-8 shows data on the distribution of potential conflicts with mission type of the involved aircraft. The substantial involvement of air carriers with each other and with other civil aircraft is indicated in this table.

2.2.3 Air Traffic Near Mid-Air Collision Data

The FAA Air Traffic Service is analyzing the various near mid-air data bases to eliminate the reporting redundancy and validate the remaining data. A preliminary analysis of 351 Department of Defense and 916 FAA Flight Standards reports were combined to form the "preliminary validated data base". It is planned to incorporate some additional 3400 NASA ASRS reports for a total composite base of about 4600. These data were collected during the 29 month period from July 1, 1976 through November 1978. Of the 1267 reports which form the preliminary validated data base from the Flight Standards and DOD data, 1144 have been validated by corroborating the information with the original incident reporters by follow-up interviews. The reporting rate for the validated data shown in Figure 2-6 is more than twice that shown in the Flight Standards data for 1975 but the percentages of occurrence in various airspace are about the same. These data show that a serious problem still exists with uncontrolled aircraft in controlled airspace.

TABLE 2-5

EVASIVE ACTIONS FOR THE REPORTED POTENTIAL CONFLICTS

(NASA ASRS data base as of 9-23-77)

EVASIVE ACTION	NUMBER OF REPORTS
Evasive Action Taken	1044
No Time for Evasive Action	136
Evasive Action Not Taken	558
Action, if any, Not Known	290
TOTAL	2028

TABLE 2-6

DISTRIBUTION OF SERIOUS POTENTIAL CONFLICTS WITH TYPE OF AIRSPACE

(NASA ASRS data base as of 9-23-77)

AIRSPACE	NUMBER OF SERIOUS* POTENTIAL CONFLICTS
Positive Control Area	48
Terminal Control Area	99
On an Airway	96
Airport Area	163
Uncontrolled Airspace	79
TOTAL	485

* A serious potential conflict is one in which the miss distance was estimated to be less than 500 feet in any direction and evasive action was taken.

TABLE 2-7

DISTRIBUTION OF SERIOUS POTENTIAL CONFLICTS WITH TYPE OF AIR TRAFFIC CONTROL

(NASA ASRS data base as of 9-23-77)

TYPE OF CONTROL	NUMBER OF SERIOUS* POTENTIAL CONFLICTS
Ground Control	10
Tower	112
Departure Control	45
Center	77
Approach Control	171
None	10
TOTAL	425

* A serious potential conflict is one in which the miss distance was estimated to be less than 500 feet in any direction and evasive action was taken.

TABLE 2- 8

DISTRIBUTION OF POTENTIAL CONFLICTS WITH MISSION TYPE OF THE INVOLVED AIRCRAFT

(NASA ASRS data base as of 3-31-77)

MISSIONS OF INVOLVED AIRCRAFT	NUMBER OF REPORTS
Scheduled Air Carrier/ Scheduled Air Carrier	157
Scheduled Air Carrier/ Other Civil Aircraft	247
Scheduled Air Carrier/ Military Aircraft	80
Other Civil Aircraft/ Other Civil Aircraft	260
Other Civil Aircraft/ Military Aircraft	137
Military Aircraft/ Military Aircraft	28
TOTAL	909

Figure 2-6

FAA AIR TRAFFIC SERVICE PRELIMINARY VALIDATED NEAR MIDAIR COLLISION REPORTS
(July 1976 through November 1978)

TOTAL REPORTS
1,267 (202)

En Route
394 (69)

Terminal
(within 30 nmi except airport area)
493

Airport
(within 5 nmi and 3000 ft.)
380

TCA & Periphery*
83

Other Terminal Area
272 (34)

TRSA & Periphery*
138

	TCA & Periphery* 83		Other Terminal Area 272 (34)	TRSA & Periphery* 138	
IFR/IFR**	20	0	24	15	2
IFR/VFA	0	1	28	1	4
IFR/UNK	20	28	160	78	18
VFA/VFA	0	1	7	1	2
VFA/UNK	7	4	20	2	2
UNK/UNK	1	1	33	10	3

*TCA or TRSA Periphery excludes the Airport Traffic Area and includes airspace within 2,000 feet and 5 nmi of the TRSA or TCA boundaries.
**IFR listings include VFR Stage III separation service.
VFA is VFR with traffic advisories.

Of the 206 TCA and TRSA encounters with at least one aircraft in communication: 72 incidents occurred after traffic call to one aircraft; 6 incidents after traffic call to both aircraft.

2.3 System Error Statistics

A study of the performance of the human element in ATC was requested by the Air Traffic Service of the FAA to support the identification of system error causes and to recommend corrective actions. The system errors* of concern are unintentional penetrations of standard minimum separation distances between two controlled aircraft. Although system errors are relatively rare events and involve a small portion of the operational work force in a given year, their occurrences may indicate where system improvements may be needed. For this reason, the Air Traffic Service established a system error reporting and prevention program several years ago. Data from this program were accumulated in the System Effectiveness Information System (SEIS), which is the source of the statistics presented in this section. The current system error rate is 1.5 per day, but less than five percent of all system errors lead to near mid-air incidents.

Figure 2-7 shows the number of system errors reported per year in both terminal facilities and en route centers. The introduction of significant equipment improvements or procedures that could be expected to have an impact on the rate of occurrence of system errors is also shown. The data suggest that introduction of En Route Conflict Alert in the centers has had a restraining effect on the growth of reported system errors. Since Terminal Conflict Alert is just now becoming operational at some of the ARTS III terminals, it will be some time before the effect of this system on the terminal system error rate will be evident. In 1975, controllers were given immunity from disciplinary action (with a few reservations) as a step toward encouraging the reporting of system errors.

System errors are currently occurring at the rate of about 500 per year. The SEIS data base does not contain data that show the closest separation for aircraft that have been involved in a system error. It is likely that in most

*A system error is an operational error which results in less than the appropriate separation minima being provided to aircraft receiving air traffic service (including minimum authorized longitudinal, lateral or vertical spacing between aircraft, between aircraft and terrain or obstacles, or between aircraft and airspace to be protected).

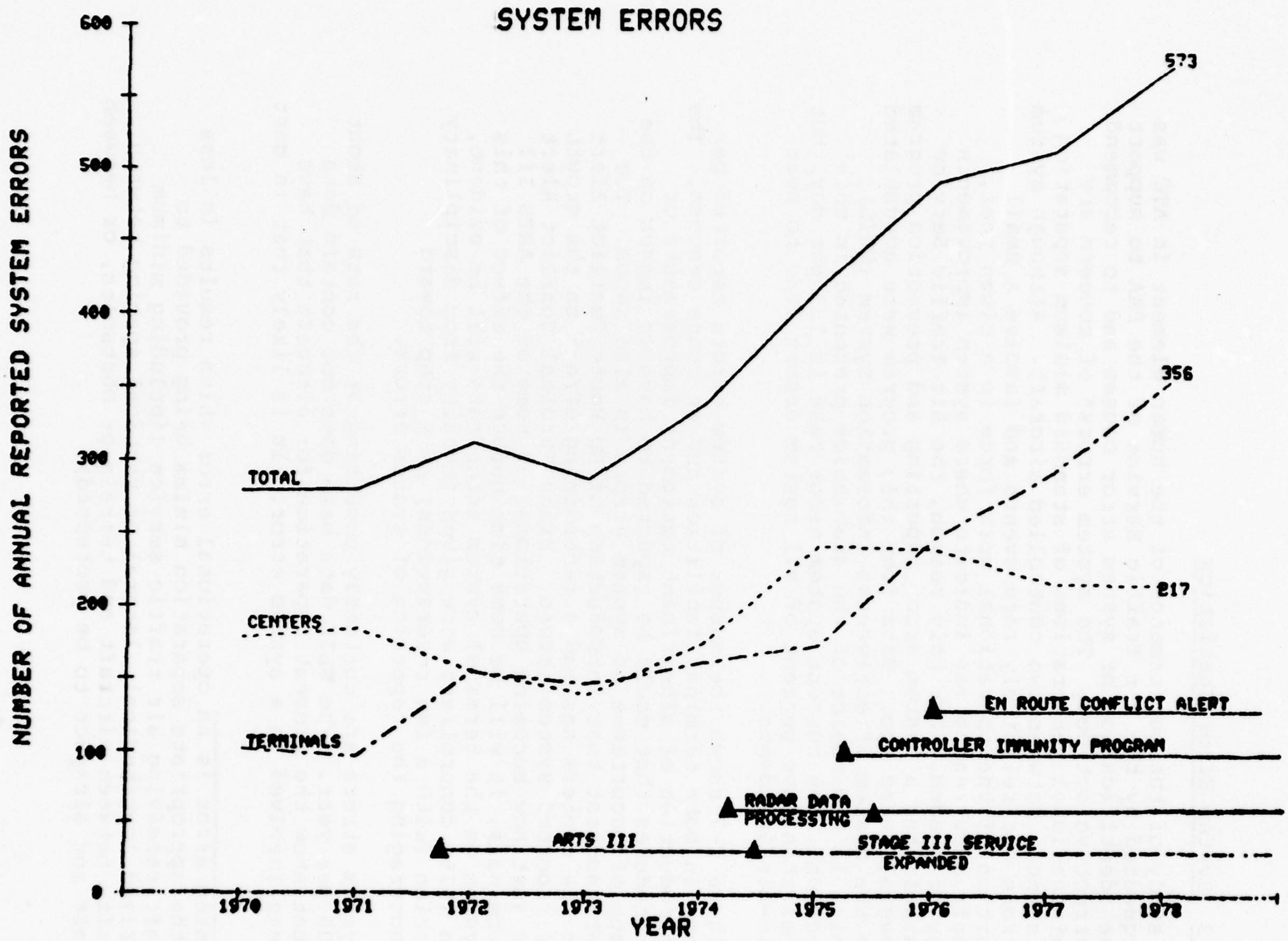


Figure 2-7
Number of Reported System Errors Per Year

of the system error cases, separations were not so close as to constitute a true collision threat, and many represent only minor violations of established separation minima. Nevertheless, they represent cases where the controller had failed to achieve his primary goal--that of keeping the aircraft separated by at least the separation minima. Even though system errors could come about through errors on the part of the pilot, it has been found that the vast majority of system errors in SEIS are the result of controller errors.

The analysis of system error probable causes and corrective actions is presented in Reference 2. This study concluded that system errors occurred over broad ranges of conditions including geographical area, experience level and age of controllers, type of control position, and workload. It was observed that the major causes of system errors were associated with work habits and control techniques. Actions that strive to improve the human performance of the controllers are currently being developed as a means of reducing the number of system errors.

Table 2-9, taken from Reference 2, presents the direct causes of system errors occurring within terminal ATC facilities and Table 2-10 presents the same for en route centers. Attention and judgment were a major factor in over three-quarters of the system errors. In perspective, only 4.8% of all system errors lead to potential near mid-airs, and less then 1% lead to critical near mid-airs. Figure 2-6 shows that only a small percentage of the overall near mid-airs occurred between aircraft receiving ATC separation service.

2.4 Altitude Deviations

Pilot deviations, including altitude deviations and course deviations, are one cause of near mid-air collisions. An altitude deviation occurs when a pilot with an ATC assigned altitude significantly overshoots or undershoots his level-off to that altitude from a climb or a descent, or departs significantly from his altitude while in level flight. Altitude deviations usually reflect human error on the part of the pilot. These can be particularly serious when they occur at intermediate altitudes that are assigned by the controller during climb-out or descent because of conflicting traffic. In this case, a failure to observe the altitude clearance has a high likelihood of leading to a potentially hazardous near mid-air collision.

TABLE 2-9

DIRECT CAUSES OF SYSTEM ERRORS AT TERMINAL FACILITIES

CAUSE	1974	1975	1976	TOTAL
Attention	32 19%	59 35%	69 30%	160 28%
Judgment	101 61%	69 41%	130 57%	300 53%
Communications	19 12%	26 15%	18 8%	63 11%
Stress	--	--	--	--
Equipment	6	3	3	12
Ops. Management	1	2	--	3
Environment	--	--	--	--
Procedures	2	7	4	13
External	3	3	3	9
No Code	1	--	3	4
TOTAL SEs	165	169	230	564

TABLE 2-10

DIRECT CAUSES OF SYSTEM ERRORS AT EN ROUTE CENTERS

CAUSE	1974	1975	1976	Total
Attention	41 25%	72 30%	71 32%	184 29%
Judgment	97 58%	135 56%	112 50%	344 55%
Communications	19 11%	25 10%	25 11%	69 11%
Stress	--	--	--	--
Equipment	5	6	7	18
Ops. Management	1	--	1	2
Environment	--	--	--	--
Procedures	1	1	3	5
External	1	1	2	4
No Code	1	-	2	4
TOTAL SEs	166	241	223	630

The NASA ASRS data base identifies those safety reports which deal with altitude deviations. The following data are based on the 4870 reports in the ASRS data base as of September 27, 1977. Of these, 228 (5%) were coded as containing an altitude deviation. Table 2-11 shows the distribution of altitude deviation reports with type of airspace, and Table 2-12 shows the distribution with type of ATC control. These data indicate that altitude deviations occur throughout the National Airspace System.

The NASA analysts studied 65 of the altitude deviations that occurred prior to January 15, 1977; results are presented in Reference 4. The following data are drawn from that reference. Table 2-13 shows the types of aircraft involved in the altitude deviation reports. Table 2-14 shows the result of the deviations with respect to separation from another aircraft. A potential conflict is defined by NASA as any perceived problem relating to the risk of airborne collision. A near mid-air collision as defined by NASA means a situation in which the aircraft were too close for evasive action. (This differs somewhat from the Flight Standards definition.) The data indicate that altitude deviations are a significant cause of near mid-air collisions in the ATC system.

Of the 65 reports studied above, 46 were considered to have sufficient detail to permit an analysis of causal factors. The results of this analysis are presented in Table 2-15. The two most prominent factors are distraction or high workload and communication. Automatic delivery of confirmation of altitude clearances and the use of an automatic separation assurance system to provide backup against these types of human errors seem worthy of investigation.

2.5 Summary and Conclusions

The number of mid-air collisions per year in the conterminous U. S. has been fairly constant for thirteen years. The fact that the number of collisions per year has not risen sharply with increased aircraft operations is due to the introduction of such systems and procedures as ATC radar and flight data processing automation, TCA and TRSA areas, increasing use of beacon transponders, and introduction of Conflict Alert. It is expected that additional steps will be required to prevent a rise in the number of collisions per year as the number of operations increases in the future.

TABLE 2-11

DISTRIBUTION OF ALTITUDE DEVIATIONS WITH

TYPE OF AIRSPACE

(NASA ASRS data base as of 9-27-77)

AIRSPACE	NUMBER OF REPORTS
Positive Control Area	51
Terminal Control Area	59
On Airways	82
In Vicinity of Airport	25
Uncontrolled Airspace	6
TOTAL	223

TABLE 2-1?

DISTRIBUTION OF ALTITUDE DEVIATIONS WITH TYPE OF AIR TRAFFIC CONTROL

(NASA ASRS data base as of 9-27-77)

AIR TRAFFIC CONTROL	NUMBER OF REPORTS
Tower	32
Departure Control	42
Center	101
Approach Control	72
TOTAL	237*

*Some reporters mentioned more than one ATC facility as involved in their occurrance.

TABLE 2-13

TYPES OF OPERATIONS INVOLVED IN ALTITUDE DEVIATIONS

TYPE OF OPERATION	NUMBER OF REPORTS
Air Carrier	38
General Aviation	8
Military	13
Unknown	6
TOTAL	65

TABLE 2-14

OUTCOME OF ALTITUDE DEVIATIONS

(NASA ASRS data base as of 1-15-77)

OUTCOME	NUMBER OF REPORTS
Potential Conflicts*	23
Near Mid-Air Collisions*	7
Less Than Standard Separation	16
TOTAL	46

*NASA definition varies from Flight Standards definition

TABLE 2-15

ALTITUDE DEVIATIONS: ENABLING AND ASSOCIATED FACTORS

FACTOR CATEGORY	ENABLING FACTOR	ASSOCIATED FACTOR
MAN		
COGNITION, DECISION-MAKING	1	4
MONITORING BEHAVIOR	4	4
SUBSYSTEM OPERATION	5	1
FLIGHT CONTROL	1	1
MISUNDERSTOOD CLEARANCES	9	1
OTHER COMMUNICATION PROBLEM	4	1
DISTRACTION, HIGH WORKLOAD	10	6
SOFTWARE		
OPERATING PROCEDURES, CHECKLISTS	0	5
NAVIGATION INFORMATION, CHARTS	2	0
SIMILAR IDENTIFIERS OR TRIP #'s.	2	0
HARDWARE		
ALTITUDE ALERT SYSTEM DESIGN	1	3
AUTOPILOT MALFUNCTION	4	0
OTHER AIRCRAFT SUBSYSTEM PROBLEM	1	1
RADAR NOT AVAILABLE OR OTS	0	2
ENVIRONMENT		
TURBULENCE UPDRAFTS	2	0
HIGH COCKPIT NOISE LEVELS	0	2
COCKPIT/INSTRUMENT LIGHTING LEVELS	0	2

There may be some apparent disparity between the collision risk indicated by the mid-air collisions and that indicated by the other safety reports. This would be most likely for the case of air carrier aircraft, which have been involved in few collisions but many safety reports. This can be explained in part by the observation that professional pilots are apparently more willing to make safety reports. In a broader sense, these data are consistent with a probabilitistic view suggesting that only a fraction of the mid-air encounters that were close enough to startle the pilots would lead to a collision.

While the fraction of near mid-air reports or system error reports that represents truly hazardous mid-air situations is certainly open to debate, there seems ample evidence within the data to indicate the continuing presence of a mid-air collision threat. For most of those safety reports that do represent hazardous situations, it is probably safe to conclude that a mid-air collision was averted only by chance and not through the actions of separation assurance systems or procedures. There is also strong evidence within the data presented here to indicate the limitations of complete dependence on human performance for separation assurance. Automated separation assurance systems have a logical role to play in providing a backup to the human performance required in the National Airspace System. However, the data do not support the notion that automatic separation assurance systems, in the near future, should supplant the present human processes as the primary means of providing separation assurance.

The major problem to be solved is the reduction of the number of near mid-air collisions. Although TCA's have been effective in reducing the problem within the TCA itself, the problem still persists outside the TCA. TRSA areas still experience a significant number of near mid-air collision reports, and VFR/IFR interactions continue to occur in and near both TCA and TRSA areas in significant numbers. Mid-air collisions generally involve uncontrolled aircraft operating in regions of low-density airspace. Although no IFR collisions have occurred recently, the increasing number of near mid-air collisions involving two such aircraft indicates the seriousness of such a threat.

3. FUNCTIONAL REQUIREMENTS FOR THE AIRCRAFT SEPARATION ASSURANCE SYSTEM

The primary requirement of the Aircraft Separation Assurance (ASA) system is to reduce aircraft collision risk measured in terms of system errors, near mid-air collisions, and mid-air collisions, particularly to controlled aircraft participating in the air traffic control system. In meeting this requirement, the ASA system should provide two different levels of backup to the controller in the performance of his aircraft separation assurance function. The first level of backup is to provide warnings on impending violations of separation minima. The second level of backup includes provision of a final fail safe collision detection and resolution function to detect and correct for human errors occurring during the resolution of a collision situation.

In addition to the IFR, the ASA system should provide final fail safe collision detection and avoidance services to equipped users operating under visual conditions or visual flight rules.

In support of the general requirement stated above, the ASA system must also meet the following related requirements:

- Operation of the automatic ASA system must be fully integrated with and compatible with the air traffic control system.
- It must offer protection in most airspace, including airspace not covered by primary or secondary radar systems.
- Each of the elements making up the ASA system must interface with each other and with the air traffic control system, and operate in a compatible and mutually supporting mode.
- The ASA system must not generate excess unwanted alerts (an alarm occurring when no separation violation has occurred).
- The ASA system must not miss alerts or fail to provide warnings on potentially dangerous threats.
- It must provide flexibility in the choice of pilot maneuvers during conflict resolution in cases where pilots see the threat aircraft.
- The logic must be capable of handling encounters involving multiple aircraft (representative of existing and expected multi-aircraft encounters).

- System operation must be judged acceptable by both pilots and controllers.
- The partial service for equipped users must be available to the first user who purchases the appropriate equipment (i.e., not requiring the equipping of a majority of the aviation fleet before a significant level of protection is achieved).

4. ELEMENTS OF THE AIRCRAFT SEPARATION ASSURANCE SYSTEM

This section describes the capabilities and performance of the various elements of the integrated aircraft separation assurance system.

4.1 En Route Conflict Alert

En Route Conflict Alert is a software function, resident in the en route automation system, that provides an aid to the controller in detecting imminent violations of radar separation minima. It is currently operational at all twenty Air Route Traffic Control Centers. The centers selectively operate Conflict Alert down to the floor of surveillance coverage.

Potential conflicts, defined by a horizontal separation parameter and an altitude separation parameter, are detected by projecting a volume of airspace constructed about each track along its velocity vector from its present position to a position some time in the future. En Route Conflict Alert typically uses a horizontal parameter of 4.8 nautical miles, an altitude of 1000 feet, and a projection time parameter of 120 seconds. If another aircraft is found within the volume of projected airspace for a given subject aircraft, a potential conflict is declared, and an indication is given on the displays for the sector(s) controlling the aircraft. The data block on the display for each aircraft involved is blinked, and additional tabular data is displayed for the controller. The Conflict Alert system depends upon the controller to assess the situation, develop corrective action, and issue verbal instructions to one or both of the pilots via radio.

En Route Conflict Alert today operates only on aircraft that are tracked by the National Airspace System (NAS) En Route tracking system and that have valid altitude information. It will operate for aircraft which do not have a beacon transponder, provided the controller initiates a track on the primary radar returns. If the aircraft does not carry an altitude reporting transponder, the controller must enter an assigned altitude for the aircraft. An aircraft with a flight plan and a transponder, either with or without altitude reporting, will receive automatic track initiation if its transponder is replying with a discrete beacon code. The controller can manually start tracks on uncontrolled aircraft.

Modifications to the NAS en route system that would provide for automatic track initiation on uncontrolled aircraft that are transponder equipped with altitude reporting are

under development. With these modifications, detection of potential conflicts between controlled aircraft and uncontrolled aircraft with altitude reporting transponders will be possible.

En Route Conflict Alert uses certain pieces of information from the flight plan of the aircraft in performing its conflict detection function. The most significant item of flight plan information used is assigned altitude. The controller is expected to update manually the altitude assignment that is stored in the computer for an individual aircraft each time a new altitude is assigned.

Additional information concerning En Route Conflict Alert can be found in Reference 8.

4.2 Terminal Conflict Alert

Terminal Conflict Alert is a software function, implemented within the Automated Radar Terminal System (ARTS) - III that provides warnings to the controller of hazardous mid-air situations between aircraft. Unlike the enroute warning system, the terminal version is not designed as an aid to avoiding violations of separation minima. Operational introduction of Terminal Conflict Alert began in early 1978.

Terminal Conflict Alert contains three alert-generating modules, each of which has a different purpose and different alert criteria. In the first and most significant, a volume of airspace defined by horizontal and vertical parameters is projected along an aircraft's current velocity vector to determine if another aircraft is a potential threat, much as is done in En Route Conflict Alert. However, the parameters used in Terminal Conflict Alert are typically 1.2 nautical miles horizontally, 375 feet vertically, and a projection time of 40 seconds. In addition, the parameters are not related to any radar separation minima as are those in the En Route system.

The second module of Terminal Conflict Alert attempts to detect vertical or horizontal aircraft maneuvers. If a maneuver is sensed, this module uses different detection equations which take into account the maneuver accelerations. The third and final module relies on current separation or constant look angle for its alert generation. Normally, all three modules are operating simultaneously. However, in the vicinity of the airport, the first module is inhibited.

The Terminal Conflict Alert system operates only on aircraft tracked by the ARTS system. ARTS automatically initiates tracks for aircraft with flight plans and discrete codes. The controller can automatically start tracks on any other transponder equipped aircraft. The feasibility of incorporating automatic track initiation for uncontrolled aircraft that have altitude reporting transponders, and of including these aircraft within the Terminal Conflict Alert calculations, is being investigated.

The Terminal Conflict Alert system uses no flight plan information. Furthermore, it can operate only for aircraft that have altitude reporting beacon transponders.

The Terminal Conflict Alert system has a provision for using different alert parameters in different regions of airspace within a single airport's terminal area. The boundaries between these regions can be specified uniquely for each individual terminal area.

At present, there is no interface between Terminal and En Route Conflict Alert. It is possible that both systems may generate an alert (to different controllers) if a conflict develops between two aircraft each of which is tracked by both the terminal and en route systems. However, the times of the alerts will usually be different because of the significantly different alert thresholds.

More information on Terminal Conflict Alert can be found in Reference 9.

4.3 Conflict Resolution

In the current versions of En Route and Terminal Conflict Alert, the output is an indication to the controller that two aircraft are potentially in conflict. No advice on a course of action for resolving the conflict is generated by the Conflict Alert system. It has been proposed that Conflict Alert incorporate additional algorithms to generate suggested resolutions for the controller. These algorithms are referred to as Conflict Resolution.

Development of En Route Conflict Resolution as an enhancement to En Route Conflict Alert is in progress. The current version of En Route Conflict Resolution is presented in Reference 10. En Route Conflict Resolution advisories will most likely be given to the controller at the same time the original Conflict Alert is displayed.

En Route Conflict Resolution displays to the controller a family of solutions indicating safe directions for resolution of the conflict between IFR aircraft. In generating the recommended strategies, some consideration is given to the flight plan intent of the aircraft. A check is made to insure that the advisory will not result in a new conflict with a neighboring aircraft.

The idea of implementing a Terminal Conflict Resolution function has also been considered. Development of a useful service for the terminal system would be considerably more difficult because of the shorter warning times and the lack of flight intent information. No baseline Terminal Conflict Resolution function has yet been defined.

4.4 Automatic Traffic Advisory and Resolution Service System

Automatic Traffic Advisory and Resolution Service (ATARS) is a ground based collision avoidance service using the surveillance and data link capabilities of the Discrete Address Beacon System (DABS). (An earlier version of ATARS was known as Intermittent Positive Control.) DABS is described in Reference 11. ATARS is currently under development, and the current design of this system is defined by Reference 12. This version will be subjected to extensive test and evaluation, beginning in 1979 using three engineering model DABS/ATARS sensors.

In order to receive ATARS service, an aircraft needs a DABS transponder and an ATARS display. Collision avoidance advisories and traffic advisories are provided automatically by the DABS/ATARS system, without human input or intervention of any kind. ATARS typically uses a horizontal parameter of one-half nautical mile, an altitude parameter of 400 feet, and a projection time of 30 seconds. ATARS will provide protection to an equipped aircraft from any intruder which carries at least an altitude reporting Air Traffic Control Radar Beacon System (ATCRBS) transponder by issuing traffic and resolution advisories to the equipped aircraft. Two types of traffic advisories are provided. The first indicates the location of a nearby aircraft, on a parallel but non-collision course, which could become a collision threat if either aircraft were to initiate a maneuver. The second type of traffic advisory indicates the location of a proximate aircraft. This second advisory is displayed with a flashing light to indicate the higher degree of threat.

The ATARS system is capable of taking into account the flight rules status of an aircraft. An aircraft can be flying according to Instrument Flight Rules (IFR) or Visual Flight Rules (VFR). ATARS minimizes interference with the flow of IFR traffic by issuing maneuvers to the VFR aircraft before issuing them to the IFR aircraft to resolve a conflict between an IFR and a VFR aircraft . Many conflicts of this type can be resolved without the need for resolution maneuvers by the IFR aircraft.

It is expected that general aviation pilots will make extensive use of ATARS-generated PWI's when flying VFR.

Since Terminal Conflict Alert and ATARS use quite similar warning times, particularly in the case of head-on collision situations in the terminal area, the two functions will be integrated. Their operation will always provide the conflict alert warning first, allow the controller the maximum time possible to resolve the conflict, and then issue the ATARS resolution advisory only at the last possible moment. This integration is described in Appendix D.

4.5 Beacon-Based Collision Avoidance System

The Beacon Collision Avoidance System (BCAS) is an airborne collision avoidance system which provides protection to a BCAS equipped aircraft from any intruder carrying at least an altitude reporting ATCRBS transponder. It also provides traffic advisories about all aircraft equipped with at least an ATCRBS transponder, with or without altitude reporting. BCAS equipment includes a display, a processor, a transmitter capable of making interrogations on 1030 megahertz, a receiver capable of receiving replies on 1090 megahertz, top-and bottom-mounted directional antennas and a DABS transponder. The frequencies used by BCAS are the same as those used by the ground surveillance systems.

BCAS is capable of operating in several surveillance modes. In a purely passive mode, BCAS can listen to the replies that surrounding aircraft make in response to interrogations from several ground ATCRBS radars (of which at least one is equipped with an azimuth reference) and can infer the position of itself relative to other aircraft. When operating within the coverage of only a single ATCRBS radar, BCAS can augment its surveillance by making its own active interrogations of the surrounding aircraft and of a fixed transponder placed on the ground at the ATCRBS radar location. When operating within coverage of a single DABS radar, BCAS can infer the positions of surrounding aircraft

by listening passively to their replies to DABS interrogations, and by listening to certain information describing the current pointing direction of the DABS antenna which is transmitted by the DABS sensor. BCAS can also operate (albeit with somewhat more limited information) outside the coverage of any DABS or ATCRBS radars by operating in a purely active mode. In this mode, BCAS makes its own interrogations and listens to the replies to those interrogations of surrounding aircraft carrying DABS or ATCRBS transponders.

Like ATARS, BCAS is designed to provide traffic advisories and to issue maneuver advisories in the last moments before collision. In each of its operating modes, BCAS exchanges information with another BCAS unit at the time of detecting a conflict in order to coordinate the advisories being displayed. BCAS generates and displays traffic advisory information on threats equipped with DABS or ATCRBS transponders, with or without altitude reporting capability. BCAS decision thresholds for advisories are comparable to those used by ATARS. BCAS is currently in the experimental stage and would not be implemented in its full capability form for several years.

The full capability BCAS described above provides service in all airspace well into the 1990 time period It will provide backup protection from human error in detecting and providing resolution advisories for conflict situations. This protection will be available to equipped users in all airspace (particularly, airspace with high aircraft densities) until ATARS is fully implemented.

A simpler form of BCAS providing limited service in low density airspace is also being developed to serve as a supplement to ATARS which will provide protection outside of ATARS service areas. This system employs only the active mode of BCAS, and as such, will not work in high density airspace. Because of being less complex and lower cost, however, the Active BCAS is expected to be implementable much sooner than the full capability version. Both the full capability and active only systems are interfaced with ATARS through the DABS data link. BCAS resolution advisories are suppressed when the aircraft operates in an ATARS service area.

4.6 Automated Terminal Service

The Automated Terminal Service (ATS) system is a low cost automatic system providing traffic advisory, and traffic pattern management services. It was designed initially as a low cost substitute for manned control towers for installation at airports as they met tower establishment

criteria. Since it provides an aircraft separation assurance capability, and it uses low cost ATCRBS, or in a later phase DABS, avionics, it has a significant potential for reducing the mid-air collision problem for general aviation airports. However, the cost of these systems may preclude their implementation at many general aviation airports, and a procedural version or self-announce type of system also exists which may have substantial benefits in reducing the collision risk, particularly at the lower-density general aviation airports. In this type system, pilots announce their positions as they progress through the traffic pattern. Although an advisory circular has been disseminated recommending this procedure, all announcements are currently made on a single frequency, which results in unsatisfactory operation in high density areas. Additional discrete VHF frequencies are needed to make the service effective in preventing mid-air collisions at uncontrolled general aviation airports.

Hence, it seems possible that ATS implementation might include terminals beyond those qualifying for manned control towers under the present criteria, based on the improved safety provided by the system. It also seems clear, however, that the procedural or self-announce system offers the best possibility for improved safety at the majority of the general aviation airports.

A feasibility model of the Automated Terminal Service system has been tested at NAFEC. Operational testing of this system has been conducted at the Robert J. Miller Air Park in Tom's River, New Jersey.

5. INTEGRATED AIRCRAFT SEPARATION ASSURANCE SYSTEM

When the team completed its examination of the ASA system elements and assessed their capabilities and shortcomings, it next defined the potential system roles for each of these elements as well as the necessary changes to these elements. The table shown in Figure 5-1 was made by the team at the conclusion of its work and provides a summary of the roles of the several system elements. Conflict alert, possibly augmented by conflict resolution, is considered to be the primary function in reducing systems errors, which in some cases result subsequently in near mid-air collisions. ATARS, when integrated with conflict alert, provides the primary defense against near mid-air collisions, and hence becomes an automated extension of conflict alert in cases where human error occurred during conflict resolution. ATARS also has a primary role in augmenting the see-and-be-seen flight regime. The role of BCAS as a part of an integrated aircraft separation assurance system is primarily in areas outside of ATARS and radar coverage including low density en route and oceanic airspace, and including low and medium density terminals. Automated Terminal Service, or a procedural version of ATS appears to be an effective solution for the terminal mid-air collisions currently occurring between general aviation aircraft at uncontrolled fields.

AIRCRAFT SEPARATION ASSURANCE FUNCTIONAL ROLES

	EN ROUTE CA-CR	TERMINAL CA-CR	ATARS	BCAS	ATS OR PROC. ATC
Mid-Air Collisions - General Aviation			P	(B)	P
En Route Mid-Air Collisions			P	P	
En Route System Errors	P		B		
Approach - Departure Near Mid-Air Collisions			P	(B)	
Approach - Departure System Errors		P	B		
High Density Tower Near Mid-Air Collisions			P		
High Density Tower System Errors		P	B[1]		
Low Density and Non Radar Areas				P (Enr)	P (Term)
Oceanic				P	

ATARS = Automated Traffic Advisory and Resolution Service
BCAS = Beacon Collision Avoidance System
ATS = Automated Terminal Service
CA = Conflict Alert
CR = Conflict Resolution
P = Primary
B = Backup
1 = "Smart" Logic May be required - Traffic Pattern Compatible

FIGURE 5-1

6. INTERFACES AND INTERACTIONS AMONG SYSTEM ELEMENTS

6.1 Development of an Interface Between ATARS and BCAS

Since ATARS and BCAS both form elements of the integrated aircraft separation assurance system, an interface between them must be defined. BCAS will provide service outside the DABS/ATARS coverage area. Within the DABS/ATARS coverage area, ATARS is to provide all separation assurance service. To provide continuous service as an aircraft enters the DABS/ATARS coverage area, it was necessary to develop an interface for exchanging separation assurance responsibility at the coverage boundary.

The objective of this task was to analyze several alternatives for the ATARS/BCAS interface and to assess the capabilities, complexity, communications requirements, and changes required to current designs for each. The scope of this task was to study coordination and communication requirements between ATARS and BCAS but not to study ATARS or BCAS resolution logic. The study assumed that the basic ATARS logic would also be suitable for BCAS with minor modifications. The study developed logic to permit a BCAS aircraft to provide BCAS protection in DABS/ATARS coverage against an aircraft below DABS/ATARS coverage. (This would be a popup intruder to ATARS.) Logic to handle multi-aircraft conflicts was also developed. Following the study of alternatives for the ATARS/BCAS interface, an alternative was selected for detailed development. Discussion of the alternatives and the description of the detailed designs for the ATARS/BCAS interface appears in Appendix C.

The logic of the BCAS avionics operates to suppress the BCAS resolution advisory whenever the threat aircraft and the BCAS aircraft are within the ATARS service area and receiving ATARS service from the ground system. The ATARS system is also advised of any proposed actions by the BCAS equipped aircraft relating to conflict aircraft not under ATC surveillance. This information is entered into the ATARS conflict table and used as a constraint in issuing further commands to the BCAS equipped aircraft should that aircraft become involved with another aircraft receiving ATARS service.

6.2 Development of an Interface Between ATARS and Terminal Conflict Alert

Since ATARS and Terminal Conflict Alert are both intended to provide protection for conflicts involving aircraft protected by Air Traffic Control (ATC), there is a need to

provide a means for coordinated operation between the two systems. The purpose of this task was to study the interaction that would exist between the ATARS collision avoidance service and the Conflict Alert warnings to the controller, if both were implemented as presently designed. A coordinated interface was then developed that minimized the undesirable interaction between the two functions.

Since the simple interfacing of the functions did not guarantee that ATARS would not preempt Conflict Alert in all situations, the two functions were integrated. This resulted in development of a Conflict Alert emulator that could be incorporated into the ATARS logic to provide alerts to the controller in the same way as Terminal (or En Route) Conflict Alert. This made it possible to develop a logic within ATARS, for conflicts involving two controlled aircraft, that would provide a warning to the controller well in advance of ATARS collision resolution advisories to the aircraft. The logic would ensure that ATARS resolution advisories would precede the Conflict Alert warning to the controller. A description of the operation of the Conflict Alert emulator in conjunction with the ATARS resolution logic for conflicts involving a controlled and an uncontrolled aircraft has also been developed.

The study of the interaction between the ATARS resolution and the Conflict Alert logics, and the description of the Conflict Alert emulator logic are presented in Appendix D.

6.3 ATS/ATC Coordination

Whenever surveillance information from an ATS system is available in another ATC facility, the ATARS/ATC interface described in Section 6.1 provides the required coordination. If the surveillance information interface is not implemented, then ATS coordinates hand-offs with the ATC system automatically either through the air-to-air link or through the ground digital interface.

7. CHANGES REQUIRED IN CURRENT FAA PROGRAMS

This section discusses changes to ongoing FAA programs that are required by the adoption of the integrated aircraft separation assurance program. These changes, both general and specific in nature, concern individual systems and system interfaces.

7.1 ATARS/BCAS Interface Design and Requirements

An examination of the ATARS interface with passive BCAS produced a concept for coordination with ATARS requiring changes to both the BCAS and ATARS operating algorithms. This design would impact the ATARS/BCAS display hardware and software, the use of the DABS formats, the ATARS site logic, and the BCAS computer algorithms. As an extension to the DABS transponder, creation is required of a Conflict Indicator Register (CIR), (either integrated with or interfaced to the DABS transponder), which stores information necessary for collision avoidance system coordination. Both ATARS and BCAS algorithms use the information contained in this structure in choosing their resolution advisories. Each uplink and downlink must contain four bits identifying the sensors that interrogate the aircraft. In addition, a fifth bit is required on the downlink to indicate when the CIR has data that must be read out. Unused bits are available on both the uplink and downlink, but minor modification of the use of several bits in the proposed DABS National Standard would be required to insure that these bits could be used for this purpose. In addition, 112 bit long message uplinks and downlinks are required instead of regular surveillance interrogations and replies while coordination is in progress. Each DABS/ATARS transponder must have this capability. ATARS must be able to receive several long replies in quick succession. Three transactions per scan are required if the intruder is a DABS aircraft, and five transactions are required if the intruder is an ATCRBS aircraft.

Additional information on the uplink and downlink include: threat aircraft identification and the appropriate resolution advisory to protect against the DABS threat aircraft; and relative tracked position and velocity and an advisory to protect against ATCRBS threats. Inclusion of a substantial amount of logic is required in the airborne ATARS display, giving it decision-making capability. Each display unit must do positional correlation, maintain and update individual conflict records, and test uplinked advisories for compatibility in addition to driving the visual display. This subject is treated in detail in Appendix C.

7.2 Conflict Alert/ATARS Interface

Simulation of the interaction between the ATARS advisory function and Terminal Conflict Alert has shown that either function could produce the first alarm and that there was no feasible method of ensuring that the alarm from Terminal Conflict Alert would precede ATARS advisories. A solution to the confusing situation this would present to the controllers calls for emulating the Conflict Alert function in the ATARS software code. At ARTS facilities being served by DABS and ATARS, Terminal Conflict Alert would be removed from ARTS. The emulator presents the controller with an alert similar to that now supplied by Conflict Alert and ensures that the alert would take place before, or at worst at the same time as, ATARS advisory generation. The feasibility of this approach has been shown via Monte Carlo simulation, and programming flow charts are available which describe changes to the ATARS code.

A description of an approach for implementing a Conflict Resolution function within ATARS is presented in Appendix D. This function generates a resolution advisory for the controller by using the same algorithms as are used to generate ATARS resolution advisories for the pilot. The resolution advisory is displayed to the controller as a family of possible resolution actions. The controller is expected to select a specific course of action from this family. If ATARS resolution advisories are required after the Conflict Resolution advisories have been selected, the advisories previously selected for Conflict Resolution will be issued directly to the pilots. The resolution advisories for the pilots will not be recomputed unless a specified minimum period of time has elapsed since selection of the Conflict Resolution advisories. The master resolution logic of ATARS must be modified so that the resolution advisories selected at the time of Conflict Resolution are saved in the pair record and conflict table structures.

7.3 Through-the-Transponder ATARS Site-to-Site Coordination

In addition to the interface mentioned above, ATARS through-the-transponder operation requires changes to the algorithms used for choice of a collision avoidance maneuver. The new information from the CIR must be checked to make sure that the aircraft is not receiving an incompatible advisory from some other ATARS site. The specific programming changes necessary for realization of this function have not yet been developed.

An existing study of the ground communications requirements for a DABS/ATARS multi-site design has revealed that high costs are associated with a design which requires a fully redundant network of dedicated ground communications lines connecting all adjacent DABS sites. This study also showed that a significant contributor to the communications costs of the current design was the requirements that adjacent ATARS sites be able to exchange conflict information within 0.3 seconds. It has been observed that aircraft activity peaks around the busy hub airports which have ARTS and is usually low in areas where DABS sites would be far apart. This suggests that only partial netting may be required.

It was the purpose of this task to investigate the feasibility of modifying the DABS/ATARS multi-site design so that the delivery time requirements for messages on the ground communications channels could be eased. The feasibility of coordinating between sites by using data stored and repeated by the transponder was also investigated. Such a method could make it possible to avoid ground communications entirely in areas where the density of aircraft was low. It is important that modification to the current multi-site logic be developed in order to reduce the costs of installing and operating the DABS/ATARS sites. It is also important that the resulting multi-site logic be fully coordinated with the ATARS/BCAS interface logic. It was another goal of this task to ensure such compatibility. A recommended approach to modifying the DABS/ATARS multi-site logic is presented in Appendix G.

7.4 Sector Processing in ATARS for Efficiency and Cost Reduction

Along with the changes in ATARS for through-the-transponder operation, a new sector-oriented approach to multi-site coordination reducing data transmission requirements on land links was proposed. However, this approach is still in the conceptual stage, and specific requirements are not yet available. Further work on the idea can proceed independently of development of through-the-transponder logic.

7.5 ATARS Beyond 50 Nautical Miles

An additional area of interest has been range limitations on ATARS performance. The effectiveness of the system beyond 50 nautical miles has been investigated via simulation. In VFR/VFR conflicts with nominal separations of 4500 feet, ATARS generated increasing numbers of false alarms. That is, ATARS issued advisories that caused the

pilot to maneuver when safe separations would have existed without the advisories. More importantly, in several instances ATARS gave advisories that directly resulted in less miss distance than would have been the case otherwise. It was found that increasing the look-ahead time to 40 seconds was necessary to achieve a reduction in the number of these ATARS-promoted errors. With the correction in use beyond 50 nautical miles, ATARS performed effectively out to ranges of 100 nautical miles for the VFR/VFR both-equipped scenarios studied. Other types of encounters will have to be studied before the question of ATARS performance to 100 nautical miles can be considered completely answered. This topic is treated in detail in Appendix A.

7.6 Improvements to ATARS Logic to Deal with Altitude Clearance Violations

In another area, an assessment of the problem of altitude clearance violations and the resulting ATARS interaction with the ATC system indicates that effective protection is possible. However, the frequency of nuisance alarms is sensitive to vertical rates of maneuvering aircraft and must be reduced through appropriate parameter settings. Simulation shows that this can be done without a significant loss of protection by reducing the immediate altitude threshold from 1000 feet to 750 feet and eliminating the use of 30-second projections to computer vertical miss distance in the case of conflicts involving high vertical rates. This subject is treated in detail in Appendix E.

7.7 Impact of Improved Vertical Surveillance on Automatic Separation Assurance

Because of the recognized difficulty of discriminating between safe altitude level-offs and broken altitude clearances when aircraft vertical rates are high, a task was defined to study the impact on this problem of several types of improved vertical surveillance. The purpose was to determine whether these improvements could provide a significant benefit to the backup protection provided by ATARS, BCAS, or Conflict Alert against altitude deviations. The effects of a higher data rate, of finer altitude quantization, and of downlinking instantaneous vertical speed from the aircraft were analyzed. The effects of these improvements were studied by using the current En Route Conflict Alert as a specific example. Although explicit logic was not developed, the degree of

improvement in detection was indicated for vertical maneuvers that might be obtained by ATARS, BCAS or Terminal Conflict Alert. Results of this study are presented in Appendix F.

7.8 Comparison of ATARS Implementation at the DABS Site and at the ATC Facility

The current designs of DABS and ATARS call for the ATARS function to be implemented within the computer complex that is a part of the DABS sensor. It was possible that ATARS could also have been implemented within the ARTS and NAS En Route computer systems. It was the purpose of this task to analyze the two alternatives and to compare their advantages and disadvantages from cost and other points of view. It was important to ensure that the current design is the most suitable one because substantial testing of this configuration is about to begin with the DABS/ATARS engineering models. If the alternative of providing ATARS from the ATC computers had been shown to be preferrable, preparation of changes to the DABS/ATARS/ATC designs would have been needed immediately. This latter alternative would also have had substantial impact on the ATARS-Conflict Alert interface. The results of this study, showing that the present design is more appropriate than the alternative, are presented in Appendix B.

8. SUBJECTS FOR FUTURE STUDY

The following presents the results of the studies supporting the FAA's review of the aircraft separation assurance problem. Some of these studies are ongoing and will be investigating additional aspects of individual subject areas. Other studies which were identified by the FAA's review were not initiated. This section summarizes the additional study that is needed.

8.1 ATARS Interaction With ATC Operations

The major subject involves analyzing and refining the ATARS logic for conflicts between an aircraft controlled by ATC and an uncontrolled aircraft. Performance of this logic will be assessed through simulation and thorough testing with recordings of live traffic obtained from ARTS. However, the recordings obtained from the ARTS extractor system include the target reports for all aircraft. Even though ARTS tracks only controlled aircraft in real time, the tracks for all aircraft can be generated post facto. Thus, the number of alerts that would be generated by ATARS if all aircraft were equipped, can be obtained from these data. The performance of ATARS with other percentages of equippage can be studied also, by randomly marking each aircraft observed as either equipped or unequipped with ATARS.

The conditions of the aircraft at the time of ATARS resolution advisories can be extracted from these data and used as input conditions for Monte Carlo simulation. This simulation can be used to determine the outcome when pilots respond to the advisories. It is particularly important to study the alert rates generated for controlled traffic by the ATARS controlled/uncontrolled logic. It is also important that consideration be given to the reactions of the uncontrolled pilots to this logic.

Additional features that might be included in the controlled/uncontrolled logic will be studied. One approach to minimizing the alert rate for uncontrolled aircraft, is to use variable alert times that are a function of aircraft speeds and geometry. The detection logic could then be made sensitive to these variables and only the required amount of alert time would be used, to achieve successful resolution by the uncontrolled aircraft.

A second activity in this area is to study the feasibility of a "traffic pattern sensitive" feature for the ATARS controlled/uncontrolled logic. In this approach, controlled traffic flows at a major airport would be

analyzed to determine if the intentions of the controlled aircraft could be inferred by comparing their positions and velocities to patterns appropriate for the known runway configuration. The benefit to the ATARS controlled/uncontrolled logic of deriving intention in this way would be evaluated. The knowledge of pattern flow could also be of potential benefit in that ATARS could avoid resolution commands which might direct an uncontrolled aircraft into one of the major patterns.

8.2 Before and After Study of Terminal Conflict Alert at Houston

An analysis of recordings of live traffic from Houston International Airport is underway in order to determine the effect of introducing Terminal Conflict Alert. Separations achieved between aircraft would be studied to see if there is an indication of improvement in safety. The study would also search for noticeable effects, such as a reduction in the number of operations per hour, that would suggest a negative impact on ATC operations. Approximately thirty hours of data were recorded before Conflict Alert was put into operation. Another thirty hours of data were recorded after Conflict Alert had been operational for several months. Measures which will be compared in the before and after data are:

a) Operations Rate

b) Conflict Alert Alarm Rate

c) Proximity and Time to Closest Approach Measures

8.3 Performance of ATARS at Longer Ranges

Data on the performance of the resolution service from the current ATARS at longer ranges exists. Improvements to the logic for uncontrolled/uncontrolled encounters in which both aircraft are equipped have been studied. Study of the performance at longer ranges for other types of encounters is still required. In addition, the effect of reduced surveillance accuracy on the traffic advisory service from ATARS will be investigated.

8.4 Reducing the Duration of Horizontal Commands from ATARS

In the flight tests of ATARS, a strong concensus was expressed by the subject pilots that the ATARS system caused the pilots to turn through larger heading changes than were required for safe resolution. Turns frequently lasted for more than 90 degrees. In a few encounters

involving fast ATCRBS aircraft in conflict with slow aircraft equipped with ATARS, the extended turns sometimes caused separations smaller then would have resulted without resolution advisories. The extended durations of the turns have resulted from the closed loop feature of the ATARS logic which continually evaluates the encounter until the resolution is observed to be successful.

A study will be conducted to reduce the duration of commands from ATARS while still retaining the closed loop feature of the logic.

8.5 Improving ATARS Performance in Turning Encounters

The flight tests and numerous simulation studies of ATARS have shown that the current ATARS cannot provide adequate protection in some turning encounters. The traffic advisory service of ATARS has been designed to prevent the pilot of an ATARS-equipped aircraft from unwittingly initiating turns that are difficult for ATARS to handle. However, this traffic advisory service cannot be effective in preventing turns by aircraft not equipped with ATARS. Thus, it is desired that the performance of ATARS be improved in the difficult turning encounters so that more protection can be offered to ATARS-equipped aircraft when an unequipped aircraft turns.

9. CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

The following conclusions can be drawn as a result of the deliberations of the aircraft separation assurance task force:

- The major problem to be solved is reduction of near mid-air collisions; the cause is primarily human error, not hardware.

- The magnitude of mid-air collisions, near mid-air collisions, altitude deviations, and system errors has been determined; the rise in altitude deviation and near mid-air collisions is continuing, and the probability of a serious collision is very real.

- Conflict Alert appears to be effective in reducing enroute system errors.

- Clearance violations or incorrect clearances, particularly in the vertical dimension, occur frequently enough to be of concern.

- Mid-air collisions occur most commonly between general aviation aircraft. Approximately one-half occur within radar coverage and could possibly be prevented by ATARS or ATS. BCAS does not appear to be an effective system for preventing these accidents, due to cost of equipment.

- Preliminary definition of the potential roles of the ASA system elements has been formulated.

- The benefits of the ASA system elements as well as those derived from the major system development program are dependent on the carriage of ATCRBS and DABS transponders.

- BCAS does not appear to be sufficiently cost effective to require mandatory implementation by all aircraft operators.

- BCAS protection against transponder-equipped aircraft is limited to approximately 75%.

- ATARS will be "smarter" than BCAS in the terminal area due to site adaptation.

- DABS with its integral data link is a key element in achieving the following:
  - assistance to the controller in reducing system errors;
  - reduction of near mid-air collision risk;
  - assistance to the pilot through provision of severe weather and wind shear information, traffic advisories, clearances, and critical messages;
  - improvements in control system productivity;
  - improvements in surveillance; and
  - system cost reduction.

9.2 Recommendations

The ASA task force recommends that the following measures be taken in the interest of fast and effective achievement of the objectives of the aircraft separation assurance program:

- Emphasis should be placed on Conflict Alert and ATARS implementation, as these two system elements offer the highest potential for reducing system errors and near mid-air collisions.
- The following DABS related issues should be expedited:
  - implementation of DABS, DABS data link, and the ATARS system;
  - achievement of needed surveillance improvements by proceeding directly to DABS without interim steps;
  - provision of critical data link services;
  - development of a plan for undergoing a transition from ATCRBS to DABS transponders;* and

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* These efforts will be considered by the Transition Planning Group.

- definition of the airspace in which transponders will be mandatory.*

o A BCAS National (and international) Standard should be established for users desiring additional protection, particularly in low density non-radar traffic areas.

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* These efforts will be considered by the Transition Planning Group.

REFERENCES

1. Simpson, T. R., Rucker, R. A., Murray, J. P., "Civil Aviation Mid-air Collisions Analysis: January 1964 - December 1971", and "Civil Aviation Mid-air Collisions Analysis: 1972 added to the 1964 - 1971 Results", FAA-EM-73-8, Addendum 1, The MITRE Corporation, McLean, Virginia, May, 1973 and December, 1974.

2. Kinney, G. C., Spahn, M. J., Amato, R. A., "The Human Element in Air Traffic Control: Observations and Analyses of the Performance of Controllers and Supervisors in Providing ATC Separation Service", Supplement 1, "Definition and Basic Concepts", Supplement 2 "Analysis of the System Effectiveness Information Systems (SEIS) Data Base", Supplement 3, "Investigating and Reporting System Errors", Supplement 4, "Effects of Mental Attitudes on the Job Performance of Controllers and Supervisors", The MITRE Corporation METREK Division, McLean, Virginia, MTR-7655, December, 1977.

3. "NASA Aviation Safety Reporting System: First Quarterly Report", April 15, 1976 - July 14, 1976, NASA-TM X-3445, September, 1976.

4. "NASA Aviation Safety Reporting System: Third Quarterly Report", October 15, 1976 - January 14, 1977, NASA TM- X-3546, May, 1977.

5. "Aircraft Accident and Incident Notification, Investigation and Reporting", FAA Order 8020.11, July 16, 1976.

6. "Airman's Information Manual", Part 1, Federal Aviation Administration, February, 1975.

7. "Aviation Safety Reporting Program", Advisory Circular 00-46, Federal Aviation Administration, May 9, 1975.

8. Hauser, S. J. Jr., "Computer Program Functional Specification for En Route Conflict Alert", MTR-7061, The MITRE Corporation, McLean, VA, October, 1975.

9. "Design Data for Conflict Alert Stage 1" Report No. ATC 10410, Sperry Univac Defense Systems, Univac Park, St. Paul, Minnesota, Revised May, 1977.

10. Hauser, S. J. Jr., Palacio, P. A., Sokkappa, B. G., "Functional Specifications for En Route Conflict Resolution Advisories", MTR-7452, The MITRE Corporation, McLean, VA, June, 1977.

11. Drouilhet, P. R., "DABS - A System Description", FAA-RD-74-189, MIT Lincoln Laboratory, Lexington, Massachusetts, November, 1974.

12. McFarland, A. L., Patel, K. R., Roberts, D. L., "Multi-Site Intermittent Positive Control Algorithms for the Discrete Address Beacon System", FAA-EM-74-4, Change 2, The MITRE Corportation, McLean, VA., May, 1976.

GLOSSARY

ACAS	Airborne Collision Avoidance System
AED	FAA Engineering and Development
AEM	FAA Office of Systems Engineering Management
AFS	FAA Flight Standards Service
ARD	FAA Systems Research and Development Service
ARTS	Automated Radar Terminal System
ASA	Aircraft Separation Assurance
ASRS	NASA Aircraft Safety Reporting System
ATARS	Automatic Traffic Advisory and Resolution System
ATC	Air Traffic Control
ATCRBS	Air Traffic Control Radar Beacon System
ATS	Automated Terminal Service
BCAS	Beacon Collision Avoidance System
CIR	Conflict Indicator Register
Comm A/B	DABS message "Communication A or B" formats
DABS	Discrete Address Beacon System
ERS	Expanded Range Service for TRSA Stage III areas
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
IPC	Intermittent Positive Control
MAC	Mid Air Collision
NAFEC	National Aviation Facilities Experimental Center

GLOSSARY (cont'd)

NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NMAC	Near Mid Air Collision
NTSB	National Transportation Safety Board
PWI	Proximity Warning Indicator
SE	System Error
SEIS	System Effectiveness Information Systems
SVFR	Special Visual Flight Rules
TCA	Terminal Control Area
TRSA	Terminal Radar Service Area
VFA	Visual Flight Rules with Radar Advisories
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
UNK	Unknown

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UNCLASSIFIED TITLE

REPORT OF THE FAA TASK FORCE ON AIRCRAFT SEPARATION ASSURANCE. VOLUME II.

ABSTRACT

(U) A TASK FORCE HAS DEVELOPED FAA ENGINEERING AND DEVELOPMENT CONSENSUS
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